Application and Recent Trends in Implementation of Internet of Things: A comprehensive review

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Abstract:

Internet of Things (IoT) is an evolving technology in the current era with a combination of diverse computational technologies, objects, animals and human. The objects in the IoT framework transmit data among themselves and they are assigned with unique numbers for identification. The communication among the network is established by identification system and functions without any centralized system. Advancement in the sensor network has made automation in numerous field and integration of soft computing technology in the IoT system has made effective decision making. The objects resides in the IoT system acts intelligent and perform the actions intelligently. The IoT based technology enhances daily life of humans via connected devices and makes living things context-aware. The information collected from sensors will be processed with the computational algorithms and effective predictions are accomplished. In this article, recent applications and soft computing algorithms are reviewed. In addition to that numerous applications based on IoT is also discussed in this article.

Keywords: *Machine learning, deep learning, IoT, intelligent object, healthcare, and automation.*

1. Introduction

The essence of IoT relies on the perception of huge variety of devices, which are interconnected and exchange information among the framework of IoT [1]. It determines the capability of interconnected devices and the interaction with other devices as well as users over the infrastructure of the network. IoT brings seamless integration among the object across the world. In today's world, the advancement of technology has made IoT devices are necessary and turned as a part of human life experience [2, 3].

In the framework of IoT, every device is interconnected with other devices in the network that communicates, transmits, retrieve data and triggers the actions intelligently. IoT technology has reduced the manpower in several fields and it can enhance the proficiency in manufacturing, transportation, smart education and innovative technologies [4, 5]. The progression in IoT enriches the development of start-ups in manufacturing, new industries, automation, cloud computing, cyber-security, artificial intelligence, and machine learning. One of the biggest complication in the incorporation of IoT is adoption. There are several descriptions and portrayals for IoT by diverse researchers, companies, and authors [5].

IoT acquires entire potential support by using the chief role intelligent object that utilizes several sensors and actuators. Object relies in the IoT system can perceive the context of the atmospheric condition. With the acquired data, the ability of the network is developed to process the service and communicate with the world. The paradigm of IoT makes the whole world as interconnected to accomplish the comfortable and safe real-time scenario. Advent of IoT has influenced numerous domains and has prominent role in the disaster management [6] and healthcare [7].

Numerous IoT products namely tracking system with fitness shoes, wearable bands for monitoring the health, smart meters, smart devices with RFID technology, real-time monitoring equipment's, and other smart devices implanted with IoT technology. Additionally, IoT application with smartphone technology provide assistance in tracking the humans and the necessary alerts can be generated [8]. The biological sensor collect the physiological information from the humans and process the gathered data with the computational algorithms. The necessary actions are taken based on the processed sensory information [9].

The robustness of IoT has made the possibility of gathering real-time sensor information from diverse sources for long duration that is simple and fast. The physiological information along with the atmospheric information are gathered and the data is processed by the computational algorithms which in turn provide the status of the every individual uses. There are numerous sensor available for recording the physiological signs namely oxygen, pulse rate, heart rate, the level of glucose in blood and pressure in blood [10, 11].

The sensors can precisely measure, store, analyse and observe the status of the every individual user. Reliable and innovative techniques of IoT accomplish the tasks in reduced time

with high benefit. The potential of IoT is ever-increasing and unlimited, which has huge impact on the society and also influences the daily life style, strategies used in business and in the industrial production. Effective machine learning [12], deep learning [13] and optimization techniques [14] makes the effective use of IoT technology [15].

The remaining of the paper is organized as follows: available bio sensors and their relevancy in current world is explained in Section 2, the applications and recent trends in IoT is discussed in Section 3, the machine learning based data analysis is given in Section 4 and the article is concluded in Section 5.

2. Varieties of Biosensors and their Applications

Biosensor is a group of physicochemical and biological element where the devices are developed to observe the biological scenario. Biosensor is utilised to identify the analyte and generate determined signals. Biosensor based application is one of the capable technology established for examining and observing the status in numerous sectors. Over a decade, several bio-sensing associated devices have been established to meet the complications confronted by numerous applications and they will generate accurate results.

The biological signals are gathered by the biological sensor, which is transformed into electronic signals. This transformation is a challenging mission due to the complexity in the electronic device that is directly assigned with biological framework. Biosensors have immense application in monitoring of environmental, quality checking in food industry, marine, industry, diagnosis in clinic, and other areas whichever necessitated accurate and reliable analyses.

Detection of glucose level and pregnancy identification are attained by the biosensors. Biosensor based application deliver enhanced stability and accurate results as compared to the traditional techniques. Recent progression in fluorescent spectroscopy, materials, nano-technology and biology have escalated the potential detection scheme of multi-marker, and sensitive detection of diverse diseases via single device [16]. Some of the applications and their usage is given as follows,

- Food processing industry, observing the context industry, checking the authenticity of food, safety and quality measurement.
- The processes of fermentation and observing the context.
- Bio-sensing technology for maintainable food protection.
- Biosensors in medical field and in smart hospitals.

- Fluorescent biosensors for the forecast of protein function.
- Biodefense applications for safety assurance and biosensors in plant biology for observing the condition of crop.

3. Application and Recent Trends in IoT

Smart wearables gather information and analyse the data, and in certain context smart decisions are taken from the processed sensor data. Based on the decision taken from the processing, needed response is delivered to the user. IoT-enabled wearable devices are considered as smart device and it can be worn externally as an accessories that can be embedded in garments, clothing, adhered with skin or tattooed and implanted with body. These wearable devices are interconnected with the Internet to gather, send and receive data that is further utilised in making smart decisions.

Wearables are significant portion in IoT and their progression is switching from simple to specialized applications. The smart wearables uses the wear-sense technology and it can interact with other array of devices namely computing technology, smart gadgets and communication paradigm. Due to the animals and humans mobility, smart wearable are turned as significant since they can gather and transmit the data over internet that provide high assistance in decisions smartly. The utilization of wearables can efficiently progress and optimize the application.

Smart wearables has the ability to enrich the quality of life, improves the safety and production. The progression of mobile network with less power, minimization in the electronic device size and sensor has made the increased usage of wearable technology. The rapid progression is witnessed in the wearable products that is adopted for numerous application during past few years. Wrist bands, smart watches, headsets, eye wears, body straps, ear buds, smart accessories, hand and foot worn devices are the few of the wearables for diverse applications. This technology also utilised in the gaming field and automation. However, the significant life-modifying application in wearable technology is identified mostly in the medical use cases and in continuous monitoring of health. The applications and the significant inference are elucidated in Table 1.

Table 1. Overview of Different IoT Sensors

Application Type	Sensor	Parameter Sensed	Node Process	Mobile App	Wearable	Connectivity	Reference
Rehabilitation	sEMG	Surface electromyography	Yes	No	Armband	BLE	[17]
	Ultra sound, IMU, RFID and Load Cell	Force, Orientation and Distance	No	Yes	Walker	Bluetooth and Wi-Fi	[18]
	Flex, Accelerometer and gyroscope	Orientation, Deflection and Acceleration	No	No	Hand and Leg	Wi-Fi	[19]
	Camera	Eye blinks and Face image	No	Yes	Face	Wi-Fi	[20]
Monitoring	Temperature and ECG	Heart rate	No	Yes	Wristband	Bluetooth	[21]
	SFH 7051	Heart rate	No	No	Wristband	Wi-Fi	[22]
	Passive breathing airflow temperature change	Respiratory	No	No	Headband	Back Scattering	[23]
	WHMIS inductive sensor and ECG	Heart rate	Yes	No	Chest, Leg and Hand	2G GPRS	[24]
	Capacitive	Respiratory	Yes	Yes	Chest	Bluetooth	[25]
	Piezoelectric or Vibration	Respiratory	Yes	No	Headband	Impulse radio and ultra wideband transmitter	[26]
	IC mounted on tablet shaped ingestible	Temperature	No	No	Finger	Coupling based on magnetic	[27]
	LM35	Temperature	No	No	Smart vest	Wi-Fi	[28]
	Pulse oximetry	Blood Oxygen	Yes	No	Bracelet	GSM or GPRS	[29]
	Piezoelectric	Blood Pressure	Yes	Yes	Cuff	Wi-Fi	[30]
	Gyroscope, audio and accelerometer	Mental Wellbeing	Yes	Yes	Wristband	Bluetooth	[31]
	Near infrared radiation	Blood Glucose	No	Yes	Finger	Wi-Fi	[32]

4. Machine Learning based Data Analysis

In the perception of AI, accumulated sensor data is stored in the system and the data is utilised in accomplishing entire task that is precise instructions in the sensor data is followed.

But in the perception of Machine Learning, algorithms are programmed for executing certain task. In other words, ML system will learn the condition of a place and execute accordingly. In Machine Learning, innovative outcome is forecasted from programming and vast amount of input data. The straight commands for decision making are not allowed in this system and it permits the system to learn the nature of the data for making any decision. The sketch of Machine learning with the AI data is enlightened in figure 1.

Figure 1. Overall Performance of Machine Learning System with AI

The machine learning algorithms inspects the data to identify the nature of the patterns and to formulate a model, which is then unified into the system to forecast the necessary future values. The progression of machine learning is comprised of three steps, they are data analysis, construction of ML model and undertaking a decision that is presented in figure 2. In the initial step, the input data is utilised for learning and the appropriate model is fabricated. In the following process, decisions are accomplishment from the constructed ML model.

Figure 2. Three Step process of Machine Learning Algorithm

Numerous existing applications are established based on the machine learning algorithms namely alpha go, google's deep mind and self-driving car. Machine learning and AI act as a identical whereas machine learning is a sub-domain of AI. For example, AI classifies the progression of future stock exchange with the assistance of patterns in the preceding stock data and in machine learning the system acquires the preceding data whereas the forecast is carried based on the condition. In the past decade, AI has exposed the exponential progression and regeneration which is due to the substantial improvements in machine learning. The machine learning is classified into three category such as supervised, unsupervised and reinforcement learning.

Supervised learning

The main intent of supervised learning is identifying the necessary function that associates the data to the appropriate labels. From the finding, new model is built and it is employed to the identical new data. In Facebook, ever photograph is branded with unique label value by the facebook. The algorithm is incorporated in identifying the appropriate peoples in the photograph and the automatic identification is commenced for new data.

Unsupervised learning

In this unsupervised learning, AI delivers the data that are categorized instead of labelling. The classified data is examined to disclose the necessary hidden patterns. From the representation of the data, new clusters are designed and further these clusters are categorized. Google utilises unsupervised learning to group the customers for posting applicable advertisement based on their latest searches.

Reinforcement learning

In the supervised and unsupervised learning, the model generation is based on the nature of the data. Once the data alters to new setup and the process of examination is attained to make new model. Reinforcement learning incorporated the continuous learning process to make the model based on the produced feedback. The reinforcement based model is iteratively established that is endlessly learned and progressed. The summarization of ML techniques in the IoT use cases are given in Table 2.

Table 2. Summarization of Machine Learning techniques in the incorporation into the use case of Internet of Things

Machine Learning technique	Use Cases	Optimized Metrics	Reference
Classification	Smart Traffic	Forecasting of traffic and Data abbreviation is increased	[33, 34]
Identification of Anomaly	Environment and Traffic	Identification of anomalies in power dataset, Forecasting of traffic and Data abbreviation is increased	[33, 34, 35]
Clustering	Smart Health and Traffic	Forecasting of traffic and Data abbreviation is increased	[33, 34, 36]
Linear Regression	Usage of Energy, analysis of market and economics	Forecasting by real-time and quantity of data is reduced	[37, 38]
Support Vector Regression	Smart Weather Forecasting	Forecasting	[39]
Support Vector Machine	All use cases	Data classification and forecasting by real-time	[40, 37]
Regression Tree and Classification	Smart Citizens	Forecasting by real-time and travel pattern identification of passengers	[37, 41]
Naïve Bayes	Smart Citizens and Agriculture	Travel pattern identification of passengers, food safety and calculating the count of the nodes	[42, 41, 43]
K-Nearest Neighbor	Smart Citizens	Travel pattern identification of passengers and learned metric efficiency	[41, 44]
Density based Clustering	Smart Citizens	Travel pattern identification of passengers, data labeling and detection of fraud	[40, 45, 41]
K-Means	Air Control, Smart Citizen, Smart City, Smart Traffic, and Smart Home	Travel pattern identification of passengers, small dataset analysis, datastream analysis, predicting the consumption of energy, detection of fraud and outlier	[46, 45, 47, 48, 41, 49]
Principal Component Analysis	Public place monitoring	Detection of fault	[50]
Feed Forward Neural Network	Smart Health	Energy consumption minimization, element states are forecasted, redundancy of the data and information is rectified	[51, 43, 38]
One Class Support Vector Machines	Smart Human Activity Control	Detection of fraud and emerging anomalies in the data	[45, 54]
Canonical Correlation Analysis	Public place monitoring	Detection of fault	[50]

5. Conclusion

Internet of Things (IoT) is a developing technology in the current era with a combination of diverse computational technologies, objects, animals and human. Advent of IoT made the work simple and easy to do. The objects reside inside the IoT system act intelligently and make decisions based on the need. IoT is widely accepted in numerous applications and effective results were acquired. The information collected from sensors will be processed with the

computational algorithms and effective predictions are accomplished. In this article, recent applications and soft computing algorithms are reviewed. In addition to that numerous applications based on IoT is also discussed in this article. The data gathered from sensor applications are processed with effective machine learning approached where the significant decisions are taken by the sensor data.

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